

5-Analysis of Beach Seine Data

Introduction

Direct impacts of beach nourishment projects on surf zone fish are not well documented (Hackney et al. 1996), but have become of increasing concern for resource managers given the growing awareness of the nursery function of this habitat. In the majority of cases studied in the southeastern United States (Nelson 1993, Peterson et al. 2000), demonstrated impacts of beach nourishment are limited to short-term reductions in infaunal biomass (an indicator of secondary production), whereas impacts to higher trophic levels are largely inferred. This monitoring study provides an uncommon opportunity to directly examine the potential impact of beach nourishment on surf zone fish abundance and distribution patterns.

Nourishment of the beach between Shark and Manasquan Inlets in New Jersey changed beach slope, contour, and elevation, as well as the vertical profile of rock groins, which were partially buried. Baseline sampling revealed that these groins were associated with relatively high abundances of several surf zone fish species and species number was typically greater in seine hauls taken at substations nearest the groins as well. Potential impacts to the fish community from the beach nourishment project could occur through several processes. The placement of sand on the beach buries, at least temporarily, existing benthic habitat, which may reduce the availability of infauna to benthic feeders. The burial of the groins may reduce the value of these structures as foraging and shelter sites. Additionally, the physical disturbance caused by dredging and the pumping of sand onto the beach may also affect fish distribution patterns. Elevated turbidity can negatively affect the physiology and feeding behavior of some fishes (reviewed in LaSalle et al. 1991, Wilber and Clarke submitted) and presumably could make areas of shoreline that are being nourished unsuitable for some surf zone inhabitants.

Baseline sampling established that silversides, *Menidia menidia* and *Membras martinica*, northern kingfish, *Menticirrhus saxatilis*, bluefish, *Pomotomus saltatrix*, and the anchovies, *Anchoa mitchelli* and *A. hepsetus*, dominated fish assemblages throughout the study area (USACE 1998). The distributions of these fishes were relatively homogeneous throughout the reference and nourishment portions of the study area during the baseline study period suggesting uniformity of habitat type. The during nourishment monitoring (1997) documented a shift in the relative species composition of the community along with several distribution patterns that appeared to be associated with the location of the beach fill operation (USACE 1999). Specifically, bluefish tended to be absent near areas where the beach was being nourished, whereas kingfish were caught in greatest abundance in these areas. The first year of post-nourishment sampling (1998) revealed no consistent patterns in the distribution and abundance of surf zone fishes that could be associated with the beach nourishment project. Results of the final year of post-nourishment monitoring (1999) are reported in this chapter along with a brief overview of project findings.

Materials and Methods

Sampling Methods. Sampling materials, methods, and locations in this study are the same as that used previously and are described in the baseline report (USACE 1998). Briefly stated, 28 stations that are separated by groins and are located approximately 0.8 km apart at the mid-point between groins were sampled over six sampling periods in the late summer and fall of 1997. Fish were collected using a 15.2 x 1.8-m (50-ft long by 6-ft high) beach seine with a 1.8 x 1.8 x 1.8-m (6 ft by 6 ft by 6 ft) bag. The net was 6-mm (0.25-in) square mesh. The stations were numbered consecutively from north to south, with stations 1-12 serving as the Reference area (designated as the North and Middle areas in WES 1998), and stations 13-28 (the South area) receiving the nourishment. The Shark River Inlet separates stations 12 and 13. Three substations were sampled at every station: A, on the southern side of the north groin; B, midway between the groins; and C, on the northern side of the south groin.

Sampling was conducted biweekly from August through October. This period coincides with occurrences of transient species that move north into the area in early summer and south in autumn (Schaefer 1967, Briggs 1975, McDermott 1983). In order to compare results more easily among years, the sampling periods for all years are listed in Table 5-1 and are referred to by their order of occurrence. Sampling was not conducted in early September 1998 and both September sampling periods in 1999 due to poor weather conditions. Forty-eight substations were not sampled during the October 17-23, 1999 sampling period due to severe weather as well.

All fishes were identified to the lowest practical taxonomic level and counted. Because it was impractical to sort large mixed catches of Atlantic and rough silversides in the field, their abundances are pooled herein and denoted as silversides. Likewise, catches of bay and striped anchovy were not segregated in the field. Consequently, they are also treated as one taxon (*Anchoa spp.*) in this paper. Standard length (SL), measured from the end of the snout to the base of the caudal peduncle, was recorded for the first 100 randomly selected fish from each taxonomic group except bluefish, for which total length (TL) was recorded. Total numbers were estimated by subsampling when extremely large numbers of fishes were caught, otherwise all individuals were counted. Wind and surf conditions were noted at the time of sampling. Weather permitting, a recording water quality sensor (HydroLab®) was deployed approximately 100 m offshore between the rock groins during sampling events, yielding data on salinity (ppt), temperature (°C), turbidity (NTU), and dissolved oxygen (mg/l).

Statistical Methods. The abundance data were highly skewed, therefore, non-parametric tests (Mann-Whitney and Kruskal-Wallis) were used to test for differences in abundance between the Reference and Beach Nourishment areas. The Bonferroni criterion was used to control for multiple tests (Wilkinson 1990). Size frequency distributions were plotted for bluefish and silversides for each sampling period to

examine overall changes in the age/size structure of the most common fishes in the study area.

Continuous temperature readings recorded by NOAA buoy #44025, located approximately 70 km east of the study area (40° 15' N, 73 ° 10' W), were used to determine water temperature fluctuations during each summer and fall of sampling. The data from this buoy were related to potential changes in surf zone finfish community structure. Although offshore water temperatures can potentially be influenced by different factors than inshore waters (e.g., Gulf Stream eddies and Hudson River discharges), the NOAA buoy water temperature data agreed within several degrees with the surf zone temperature data recorded by the water quality meter that was deployed at the time of sampling. Turbidity readings (NTU) taken at ten-minute intervals by the water quality meter were averaged and graphed for each station. When extremely high values occurred, the median measure for that station was used.

Results

Species Composition and Diversity. Thirty taxa and 82,473 individuals were captured during the four sampling periods in 1999 (Table 5-2) resulting in the highest overall catch/haul (296 fish/haul) for any year of sampling. Values for years 1995-1998 were 66, 80, 135, and 177 fish/haul, respectively. Silversides were numerically dominant in 1999, comprising nearly 50% of the catch in both the Reference and Beach Nourishment areas (Figure 5-1). Atlantic menhaden (*Brevoortia tyrannus*), weakfish (*Cynoscion regalis*), summer flounder (*Paralichthys dentatus*), northern puffer (*Sphoeroides maculatus*), and blueback herring (*Alosa aestivalis*) abundances were also elevated substantially over the catches of previous years (Table 5-2), especially when considering the abundances in terms of number of fish/haul. Counts for blueback herring in 1999 may have included other clupeidae (Table 5-2). Anchovy catches in 1999 occurred almost exclusively in the Beach Nourishment area where anchovies made up 28% of the total catch (Figure 5-1). The relative contribution of bluefish to the total catch returned to levels observed during the baseline years of sampling.

The number of species captured per haul in 1999 ranged from 0 - 8, with most hauls containing two to three species. For all five years of sampling, significantly more species were captured at groin substations (A and C) than at the mid-groin substations (B, all p-values < 0.05, Figure 5-2). Species richness did not differ between the Reference and Beach Nourishment areas for any sampling period in 1999.

Species Abundance and Distribution

Seasonal - The percentage of hauls in which no fish were caught in 1999 was 7.2%, which was lower than previous years, which ranged from 11.2 - 32.6%. Silverside abundance was highest in August, exceeding 200 fish/haul for both sampling periods (Figure 5-3). Bluefish captures/haul in August 1999 were comparable to seasonal catches of other years. Because sampling did not occur in September, which is when bluefish

abundances peaked in high abundance years (1997 and 1998), it is difficult to draw comparisons between overall bluefish abundances in 1999 to other years.

The autumnal drop in water temperature is associated with an emigration from nearshore temperate habitats for many marine species. Fish abundances declined in this study, as well, during the October sampling periods of all years. The continuous water temperature data recorded by the NOAA buoy permit an examination of the appearance and departure of species with relation to temperature fluctuations (Figures 5-4 to 5-8). Throughout the five years of sampling, there were only a few species that were captured in relatively high abundances that were not already present during the first sampling period. For instance, mullet (*Mugil curema*), jacks (*Caranx hippos*), white perch (*Morone americana*), menhaden, gizzard shad (*Dorosoma cepedianum*), and anchovies were not consistently captured in all sampling periods during the years they were captured at all. White mullet were consistently captured in the latter half of the study period when water temperatures typically had dropped below 20 °C. White perch also appeared late in the sampling period in 1996 (Figure 5-5). In 1997, peak abundances of gizzard shad and mullet occurred in early October (Figure 5-6), whereas anchovies were captured in greatest abundance in October in 1998 and 1999 (Figures 5-7 and 5-8, respectively).

Water Quality - Turbidity measures are available for most stations during the first three sampling periods in 1999, but are unavailable due to rough water conditions at many stations during the last sampling period in October (Figure 5-9). Overall, turbidity measures were relatively low throughout the study area, reaching a high of approximately 50 NTU at two stations north of the Shark River Inlet in late August. There were no weather related conditions noted to account for the elevated turbidity at these stations. There was also no indication of turbidity plumes occurring near the Shark River Inlet (between stations 12 and 13) or Manasquan Inlet (south of station 28). Overall, turbidity ranged from less than 5 NTU to 54 NTU, with a median of 8.4 NTU.

Geographical -

Rock Groins. Bluefish in 1999 were captured in significantly higher numbers at substations near the groins (A and C) than at mid-groin substations (B) for the first sampling period of August (Mann-Whitney U = 1007, $p < 0.05$; Figure 5-10). While bluefish were more abundant at the groin substations for the other two sampling periods with sufficient data to analyze statistically (August 23-25 and October 4-8), these trends were not statistically significant. There were no differences in the number of silversides captured at the groin versus mid-groin substations for any sampling period in 1999 (Figure 5-11 and 5-12).

Reference versus Beach Nourishment Stations. The distribution of fishes between the Reference and Beach Nourishment areas was relatively homogeneous, with a statistically significant difference appearing only for silversides in the first sampling period. More silversides were captured at the beach nourishment stations at this time (Mann-Whitney U = 427, $p < 0.001$). Bluefish abundances did not differ between the

Reference and Beach Nourishment areas for any sampling period. The predominance of anchovies in the Beach Nourishment area (Figure 5-1) is due to the capture of nearly 11,000 fish at substation 14A on October 6th, 1999. The second highest single haul of anchovies was only 778 fish, thus illustrating how influential a single haul of thousands of fish can be to the depiction of relative annual abundances.

Size Frequency Distributions. The size frequency distributions for bluefish were combined for the August and October sampling periods, respectively and included in a composite figure showing results for all years (Figure 5-13). As with previous years of sampling, three cohorts of recruits are discernible for 1999. During the August sampling periods, the peak modal size class is 50-74 mm TL, increasing to 75-125 mm TL by October. New recruits (< 50 mm TL) are apparent in the October sampling periods of all years. Spring-spawned fish from the South Atlantic Bight are dispersed northward by the Gulf Stream and move into New Jersey estuaries and nearshore habitat in late May and early June at a size of 50 to 70 mm TL (Nyman and Conover 1988, McBride and Conover 1991). Summer-spawned bluefish from the Middle Atlantic Bight arrive in New Jersey estuaries in mid- to late August at a size of 40 to 60 mm TL (McBride and Conover 1991). The different cohorts are depicted distinctively in Figure 5-13.

Bluefish were segregated by size class within the study area in 1999 (Figure 5-14). Most bluefish were less than 75 mm TL in August; however, by early October larger fish (>100 mm TL) were present throughout the study area along with samples comprised exclusively of new recruits (< 50 mm TL). Very few new recruits were included in the hauls of larger bluefish.

Silverside modal size increased throughout the study period (Figure 5-15) from 60-70 mm SL in early August to 80-90 mm SL by mid-October. There was no evidence of more than one age cohort of silversides or apparent geographic segregation by size, i.e., each haul was comprised of a representative subsample of the size range caught during that sampling period. Fish size did not differ between the Reference and Beach Nourishment areas or among substation types (all p-values > 0.1).

Discussion

The baseline sampling in 1995 and 1996 established that there were no consistent differences in fish assemblages among the 28 stations, suggesting a relatively uniform habitat type in both the Reference and Beach Nourishment areas (USACE 1998). The species composition of the fish community was similar to that reported for surf zone fishes in the South Atlantic Bight (Hackney et al. 1996). The surf zone finfish community sampled during the baseline period was characterized (USACE 1998) as being:

- Numerically dominated by silversides,
- Relatively homogeneous in species composition and abundance over the area of beach slated for nourishment and the Reference area, and

- Higher in fish abundance and species diversity at the substations closest to the groins.

A substantial change in surf zone community structure occurred in 1997, coincident with the beach nourishment project. Comparisons between 1997 and the baseline years revealed a dramatic increase in bluefish abundances throughout the study area in 1997. The increase in bluefish was not restricted to the Reference area, although bluefish abundances were greater in the Reference than the Beach Nourishment area during three of the six sampling periods. Bluefish catches were higher in the Beach Nourishment area than they had been during the baseline years (USACE, 1999). The number of species captured per haul and the abundances of ten other species also increased in 1997 throughout the study area over baseline observations. While bluefish abundances were low near active beach fill operations, kingfish were caught in higher abundances at the beach nourishment stations. Physical factors accounting for the change in distribution by species may include the avoidance of or attraction to suspended particulates in the water column. During the beach nourishment project, turbidity measures for some sampling periods were elevated within several stations of the site of the fill operation, which may account for some of the observed distributional patterns. The overall increase in bluefish abundance and species richness in 1997, however, appears to have incidentally coincided with the beach nourishment project rather than result from its operation (USACE, 1999).

Analysis of the first post-nourishment year of monitoring (1998) did not reveal any long-term impacts to surf zone finfish distribution and abundance patterns (USACE, 1999). Total overall fish abundances were higher in 1998 than in preceding years (Table 5-2), even though only five sampling periods were conducted rather than six. This high fish abundance is due, in large part, to the capture of a large number of bay anchovies in mid-September and mid-October. Decreases in water temperature, which are related to the offshore emigration of bay anchovies in the Middle Atlantic Bight region (Voughlitois et al. 1987), account for the seasonal occurrence of bay anchovies in the study area. The relative abundances of resident fish species differed in 1998 from previous years, but these fluctuations also appeared to reflect natural variation rather than a nourishment-related impact.

The surf zone fish community sampled in August and October of 1999 did not differ appreciably in fish abundance or diversity from these parameters examined the preceding four years of sampling. The fish assemblages were numerically dominated by silversides, which were also the most common taxon in 1995 and 1996. Sampling was not conducted in September, the peak month for bluefish catches in previous years (Figure 5-3), therefore, it is not clear whether a decline in bluefish abundance from the two preceding years occurred or whether the lapse in sampling missed peak catches. The sporadic, and perhaps haphazard, encounters with schools of anchovies continued to have a significant influence on the relative abundances of species in the total annual catch.

Conclusions

Because the surf zone habitat is difficult to sample, few long-term studies have documented inter-annual variation in fish population dynamics. An overview of 23 studies of surf zone fishes sampled by beach seine indicates the study of longest duration was six years, with a median study duration of two years (Wilber et al., in review). The present monitoring study spanned five years (with an additional year of preliminary data), which places it at the long end of studies of this type. Because inter-annual variation of surf zone fish community dynamics is considerable, it is unlikely that anything other than catastrophic environmental impacts on surf zone fish populations would be evident. In this study, 296,170 fish were captured from 1995-1999 through 2,190 beach seine hauls, which far exceeds the level of effort undertaken in the aforementioned studies. Clearly the sampling protocol was sufficient to detect potential impacts that were greater in magnitude than the background natural variation. Deleterious impacts to surf zone fishes, however, were not evident. Findings concerning the impacts of beach nourishment on surf zone fishes can be summarized as:

- Low bluefish abundances in the immediate vicinity of the beach fill operation in late September 1997,
- The potential attraction of benthic feeders to the nourishment area, either related to resuspended benthic material (silversides in late October 1997) or the general nourished condition (kingfish), and
- The absence of any sustained biological indicator, i.e., fish abundance or distribution pattern, that distinguishes nourished from non-nourished beach habitat.

Literature Cited

- Briggs, P. T. 1975. Shore-zone fishes of the vicinity of Fire Island inlet, Great South Bay, New York. *New York Fish and Game Journal* 22: 1-12.
- Hackney, C. T., M. H. Posey, S. W. Ross and A. R. Norris. 1996. A review and synthesis of data on surf zone fishes and invertebrates in the South Atlantic Bight and the potential impacts from beach nourishment. Contract Report to the U. S. Army Engineer Wilmington District, 111 pp.
- LaSalle, M. W., D. G. Clarke, J. Homziak, J. D. Lunz, and T. J. Fredette. 1991. A Framework for Assessing the Need for Seasonal Restrictions on Dredging and Disposal Operations. Technical Report D-91-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS
- McBride, R. S. and D. O. Conover. 1991. Recruitment of young-of-the-year bluefish *Pomatomus saltatrix* to the New York Bight: variation in abundance and growth of spring- and summer-spawned cohorts *Marine Ecology Progress Series* 78: 205-216.
- McDermott, J. J. 1983. Food web in the surf zone of an exposed sandy beach along the mid-Atlantic coast of the United States. pp. 529-538 *In* *Sandy Beaches as Ecosystems*, A. McLachlan and T. Erasmus (eds.). Port Elizabeth, South Africa.
- Nelson, W. G. 1993. Beach restoration in the southeastern U.S.: Environmental effects and biological monitoring. *Ocean and Coastal Management* 19: 157-182.
- Nyman, R. N. and D. O. Conover. 1988. The relation between spawning season and recruitment of young-of-the-year bluefish, *Pomatomus saltatrix*, to New York. *Fishery Bulletin* 86: 237-250.
- Peters, D. J. and W. G. Nelson. 1987. The seasonality and spatial patterns of juvenile surf zone fishes of the Florida east coast. *Florida Scientist* 50: 85-99.
- Peterson, C. H., H. C. Summerson, E. Thomson, H. S. Lenihan, J. Grabowski, L. Manning, F. Micheli, and G. Johnson. 2000. Synthesis of linkages between benthic and fish communities as a key to protecting essential fish habitat. *Bulletin of Marine Science* 66: 759-774.
- Schaefer, R. H. 1967. Species composition, size and seasonal abundance of fish in the surf waters of Long Island. *New York Fish and Game Journal* 1, 1-46
- Voughlitois, J. J., K. W. Able, R. J. Kurtz, and K. A. Tighe. 1987. Life history and population dynamics of the bay anchovy in New Jersey. *Transactions of the American Fisheries Society* 116:141-153.

- U.S. Army Corps of Engineers. 1998. The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury to Manasquan Section Beach Erosion Control Project. Phase I. Pre-Construction Baseline Studies. Report to the U.S. Army Engineer New York District. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- U.S. Army Corps of Engineers. 1999. The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury to Manasquan Section Beach Erosion Control Project. Phases II and III. During Construction and 1st Year Post-Construction Studies. Report to the U.S. Army Engineer New York District. U.S. Army Engineer Research and Development Center, Vicksburg, MS.
- Wilber, D. H. and D. G. Clarke. Accepted for publication. A review of suspended sediment impacts on estuarine fish and shellfish with relation to dredging activities. North American Journal of Fisheries Management
- Wilber, D. H., Clarke, D. G., Burless, M. H., Ruben, H. and W. J. Will. In review. Spatial and temporal variability in surf zone fish assemblages on the northern New Jersey shoreline.
- Wilkinson, L. 1990. SYSTAT: The System for Statistics. Evanston, IL: SYSTAT, Inc.